State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #3:
Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

By

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Peer Review of Technical Memorandum #3:

Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

Revised Draft dated September 10, 2009

a. Interpretation of key literature, identifying factors that increase the levels of pathogen indicators and risks to human health at the beach.

Caution should be used in association of indicator bacteria with human waste, as is suggested on page T3-3, in two places. In the first sentence, referring to Table 1: "**Highlighted measures on the chart are fecal-indicator-bacteria values in human** waste which [sic, grammar incorrect] the water quality objectives for protection of body contract [sic, typo, should be "contact"] recreation." [emphasis added] The data in Table 1 are not per se values in human waste. The table caption is more accurate: "End-of-pipe Effluent Bacteria Densities," and should be used in the text. Also on page T3-3, paragraph 2, the last sentence mischaracterizes the link between Enterococcus and human waste: "Importantly, the occurrence of Enterococcus in groundwater at these wells **illustrates that human waste is present** in the groundwater at the study site." [emphasis added] The EPA document provided: Health Effects Criteria for Marine Recreational Waters, reported the results of a study at Lake Ponchartrain which stated that although Enterococcus may have been the most reliable indicator of recreational water quality, it was "not specific for human wastes." Other studies, including the epidemiologic studies of Haile et al (1999; 1996) found Enterococcus in storm water. In the glossary of Haile et al (1996), Enterococcus is described as: "A bacteria that is part of the normal flora found in human **and animal** waste." [emphasis added] Therefore, the sentences in the report overstate the association of Enterococcus with human waste compared with scientific literature.

Although not directly related to literature, some of the data in Table 1 (page T3-3) seem questionable. For the Malibu Colony Plaza, the numbers of total and fecal coliform are identical, and typically fecal coliform are a log unit less than total. Also the number for Enterococci is higher than either total or fecal coliform, which is atypical in general, and not consistent with other samples. For Fire Station 88, the data are more puzzling. In all samples, the MPN for Enterococcus is equal to or greater than either total or fecal coliform MPNs. Other sources (Metcalf and Eddy, 2003, citing Crook, 1998) suggest Enterococci density is two to three logs less than fecal coliform and three to four logs less than total coliform bacteria density in raw sewage. In one sample from the Fire Station the Enterococcus MPN is one log higher than the total coliform. MPN in one sample; total and fecal coliform and Enterococcus are identical in another sample. These data would be questioned by anyone familiar with the typical trends for these three indicators reported in the literature and therefore some explanation of the differences should be offered.

There is a small inconsistency in the 1996 study by Haile et al and Technical Memo #3 in the use of the high cutoff for Enterococcus. Haile et al report the exceedences of a high cutoff of 106 MPN/100 ml (Tables 12 and 13); while the Memo uses 104 MPN/100 ml, the actual standard.

b. Interpretation of the Haile et al epidemiology study and the 1983 EPA marine health criteria for health risk

The Haile et al epidemiology study was based on illness resulting from swimming at or near storm drain outfalls. The 1983 EPA document, Health Effects Criteria for Marine Recreational Waters was based on studies of illness linked with treated wastewater outfalls. These are both point sources at beaches. The mechanism for transport of septic tank and subsurface infiltration systems such as those in Malibu is through porous media, which may alter the risk of these discharges. One source of difference resulting from subsurface discharge is the removal of particulate matter and attached bacteria. The 1983 EPA Health Effects document noted that removal of suspended solids during wastewater treatment reduced the density of Salmonella.

c. Application of correlation coefficients (Figures 7, 8, and 9) referring to attached table sent 9/10/09

Use of correlation coefficients to show consistency of Enterococcus density frequency distributions from 2005-2008 at the three beach sites is acceptable, if unusual. Typically, bacteria counts, in this case for any year at any location, can be fitted to a Poisson Distribution by regression, and then comparing the mean, μ (which also equals the variance for the Poisson Distribution). Also, showing the frequency distributions as histograms rather than line graphs is more typical.

d. The conclusion, on pages T3-7 through T3-9, that water quality persistently fails to meet water quality objectives during dry weather at Surfrider Beach, Malibu Colony Beach, Malibu Pier Beach, Carbon Beach, and Marie Canyon

The conclusion that water quality is impaired at the five beaches as measured by Enterococcus counts exceeding the single count maximum (104 MPN/100 ml) is justified, although the degree of bacterial impairment varies among the five sites. It is interesting that there were no exceedences of the 104 MPN/100 ml standard at three of the beaches (Surfrider, Malibu Pier, and Carbon) in 2008. Haile et al. (1999) reported large increases in relative risk of a number of adverse health effects (skin rash, highly credible gastrointestinal illness, diarrhea with blood) when swimmers were exposed to these levels of Enterococcus.

e. The conclusion that groundwater, contaminated with indicators of pathogens, is a source of impairment to lagoon and beaches.

This conclusion is addressed on pages T3-20 – T3-23. There are two issues in this section. First is that septic tank discharge causes bacterial (and other pathogen) contamination of groundwater, and the second, implied, is that the discharge of groundwater contaminated with pathogens is a source of ocean/beach water quality impairment, presumably a significant source if removal of OWDS's from the Malibu Civic Center area is to result in improvement of beach water quality. The section *OWDS Systems and Transportation* [sic, "Transport" is probably the more appropriate term*] of Pathogens,* needs some editing for grammatical errors, e.g., "filtrated" instead of filtered in paragraph 1, line 6 on page T3-20 and "septic bacteria" in the same paragraph, line 9 which probably should be indicator bacteria. Paragraph 3, which cites the results of Stramer and Cliver which concern septage, not septic tank effluent, is irrelevant and should be deleted unless its relevance is explained. Most of the literature cited on pathogen indicator transport from OWDS's concerns viruses, and the last paragraph of this section, in paragraph 1 on page T3-21, provides a good explanation of the limitation of using bacterial indicators, which have different transport characteristics than viruses, to predict viral pathogens. In addition, as the paragraph points out, bacterial indicators are conservative, and also have been correlated with viruses from OWDS's.

The next section cites literature related to beach pathogens. The first paragraph summarizing the papers of Yamahara et al and DeSieyes et al does not provide strong support for the importance of septic systems with beach Enterococcus, especially as compared with other sources and transport mechanisms. A later citation of Yamahara et al (paragraph 5, page T3-21) is similarly weak support for the importance of OWDS's as a source of Enterococcus. The work of Borchardt et al was done in central Wisconsin and is not relevant to beaches. Paragraph 1 on page T3-22, citing DeSieyes, is almost impossible to understand. The AAAS review of MRSB has no mention of OWDS's and should be deleted unless a better connection besides ocean water and beaches is made.

The scientific basis for Figure 11 is weak, both as support for transport and Enterococcus density. The MPN values for Enterococcus shown in Figure 11 are very difficult to justify compared with other reports (see comments above). Metcalf and Eddy report a range of $10^4 - 10^5$ MPN/100 ml for Enterococcus in raw sewage. Figure 11 has residential septic tank effluent Enterococcus at 10^7/100 ml, and one commercial system as high as 10^8/100 ml. Also the ranges of non-detect (ND) to 10^7/100 ml and ND to 10^6/100 ml are so large as to be meaningless. The one very high MPN value in Table 1 which provides only minimal evidence is suspect (as discussed above).

Overall, the movement of groundwater from the area served by OWDS's is well documented in other reports (Tech Memo 4). Literature cited confirms that pathogens, especially viruses, are transported in the subsurface from OWDS's, and would therefore reach the ocean water, especially in a sandy aquifer with short travel time. The presence of Enterococcus in septic tank effluent, nearby groundwater, and the beaches is credible support for the contribution of OWDS's to contamination of the Malibu beaches by bacteria.

Overarching questions:

a. Are there additional scientific issues, not described above, that are part of the scientific basis of the proposed rule? If so, please comment with respect to the statute language given above.

A particular source of pathogen risk is associated with the fact that OWDS's serve a small number of people. This was discussed in the EPA Health Effects Criteria for Marine Recreational Waters (1983, page 49). That document notes that when the number of individuals who are sources of fecal waste becomes smaller, the ratio of pathogen-to-indicator density will vary highly from numbers based on aggregate wastes from a large population. If one or a small number of individuals in these small systems have an infectious disease, the ratio could approach 1, making the risk significantly higher than that addressed by the water quality standard. The EPA document advises in that case, which may include OWDS's: "The solution is administrative action prohibiting such discharges into recreational waters."

b. Taking each of Tech Memo #3 and #4 as a whole, is the conclusion of each tech memo based on sound scientific knowledge, methods, and practices.

Taken as a whole, the conclusions of Technical Memos #3 and #4 are based on sound scientific principles and reasoning. Epidemiologic studies cited provide a strong basis for increased health risks to swimmers and the presence of indicator bacteria measured at the beaches, especially Enterococcus, at concentrations higher than marine recreational water quality standards. There are some relatively minor concerns about interpretations of literature and some of the reported data as discussed above and in the previous comments on Tech. Memo #4. Addressing these will acknowledge real uncertainties that always exist with environmental studies, but will not weaken the conclusions.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

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Peer Review of Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life, by Tony Calloway, P.G., Orlando Gonzalez, and Dr. C.P. Lai, P.E.

JoAnn Silverstein, Ph.D., P.E.
September 12, 2009

Determination for issues requested in Attachment 2: Description of Scientific Issues to be addressed by Peer Review.

a. *Approach used to compile an inventory of wastewater discharges from OWDSs in the Malibu Civic Center area, which staff estimates to total 255,000 gallons per day.*

Residential wastewater flow was estimated to be 100 gal/toilet/day, which is assumed to represent the wastewater generated by one person. The 349 residences had 1,263 bathrooms producing the estimate in Table 1 of 126,300 gal/day of residential wastewater. The rationale for the one person per toilet equivalent is not given. However, accepting that equivalent, 100 gallons per capita per day (gpcd) is high for households of more than two persons. A more recent text estimate for domestic wastewater flow rates for households of 3 – 4 persons is 41-71 gpcd (Metcalf and Eddy, 2003). The Onsite Wastewater Treatment Systems Manual (USEPA, 2002) reports estimates of residential wastewater ranged between 50 and 70 gpcd for homes built before 1994. For newer homes with water-saving fixtures, the reported range of wastewater flow rates was 40 – 60 gpcd. The US Census Bureau estimated that the average household size (1998) was 2.7 people per residence. With 349 residences with on-site systems, the population equivalent based on Census data would be 942, and the corresponding wastewater flow rate using the more conservative EPA flow rate range (pre-1994 homes) would be 47,000 to 66,000 gal/day, approximately half or less than the flow rate estimated in Table 1: 126,300 gal/day. Another method to estimate wastewater flow is to use the number of bedrooms, and assume 1 – 1.5 people/bed. Since the number of bathrooms and bedrooms are nearly identical in Malibu, this would produce a population range of 1,263 to 1,894, and a flow rate range, using the EPA per capita flow rate range of 63,000 to 133,000 gpcd. Only the most conservative assumptions of 1.5 persons per bedroom (or bathroom) and 70 gpcd wastewater flow produce flow rate close to the value in Table 1. For one person per bathroom (and bedroom), at the high per capita flow rate, the estimated residential flow is 88,400, 30% lower than the Table 1 value. The high residential wastewater flow rate estimated in Table 1 is not well justified given estimation methods reported in the literature. Consideration should be given to characterizing the uncertainty in the residential wastewater flow estimates, including reporting values with fewer significant figures than 4 – 6 significant figures in Table 1 entries.

For commercial properties, flow data were available for permitted sites that were assumed to be representative of average flow rates. Flow data for unpermitted sites was estimated but the method used was not reported. For example, the basis for 400 gal/day for small commercial facilities should be given. Also, it would be useful to indicate in Table 1 which commercial facilities were unpermitted. In addition, the percent of the commercial flow estimate of 128,469 gal/day that was estimated would provide a better indication of the uncertainty in the commercial flow rate estimates.

b. The methodology use to calculate loads of nitrogen from wastewaters discharged from OWDS's in the Malibu Civic Center area; specifically staff's interpretation of published literature and assumptions use to calculate nitrogen loads released from OWSDS's for those discharges where real data were not available.

Residential nitrogen loads were estimated assuming that wastewater discharged from septic tanks contained 45 mg/L total nitrogen. Estimates of residential septic tank effluent (STE) nitrogen concentration range from 40 to 100 mg/L, depending on influent water quality, tank hydraulic and solids residence times (USEPA, 2002). The total nitrogen mass loading from residential on-site systems was estimated to be 47.429 lb/day (too many significant figures!), based on the estimated residential flow rate of 126,300 gal/day and average STE total nitrogen of 45 mg/L. As a check, the estimate of 0.03 lb-TKN/cap/day (Metcalf and Eddy, 2003) and the population estimate based on bathroom number were used to calculate a total nitrogen loading from residences in the study area: to be 38 lb/day. Assuming no attenuation of nitrogen in a septic tank, this is ~19% lower than the estimated daily loading rate from residences of 47 lb/day in Table 1. Most literature reports indicate that almost 90% of the nitrogen in STE is in the form of ammonium. Removal of nitrogen in a subsurface wastewater infiltration system (SWIS) or leach field occurs by a combination of sorption, biomass uptake, and nitrification-denitrification and was estimated in the groundwater loading section of Technical Memorandum #4, as summarized in Table 3.

Eight businesses served by package plants appeared to be the only commercial discharges where effluent total nitrogen data were available. These plants constituted 46% of the estimated commercial flow (59,000 gal/day) but had consistently lower effluent nitrogen than other commercial discharges, constituting 8 lb-TN/day, which was only 19% of the daily total nitrogen load in the study areas (42 lb/day).

Commercial septic tank effluent not reported was estimated, typically as a fraction of BOD, the second of two key assumptions (page T4-5, paragraph 1). (By the way, the callout for Table 2 in this paragraph appears to be wrong. The nitrogen loading spreadsheet is Table 1.) It is widely recognized that some commercial facilities, particularly restaurants, have very high BOD concentrations compared with residential wastewater. However, the 0.18 – 0.21 TN:BOD ratio from the literature which was used to estimate the total nitrogen concentration in commercial wastewater effluent was based on <u>residential</u> wastewater characterization, where as much as 78% of the nitrogen comes from toilet waste (urea) (USEPA, 2003, Table 3.8). In restaurants, the excess BOD probably comes from food waste, oil, and grease, which should have a generally lower TN:BOD ratio. One study (Converse et al, 1984) found restaurant that septic tank effluent total nitrogen ranged from 30 to 82, with a flow-weighted mean of 57 mg/L and an average TN:BOD ratio of 15.6 g-N/g-BOD_5. This is a concern in the reliability of the commercial wastewater nitrogen loading estimate. Nine commercial discharges had estimated nitrogen concentrations ≥ 75 mg/L and were 27% of the commercial wastewater flow. Together the nitrogen discharged from them was 9,000 lb-TN/year, which was 58% of the total commercial nitrogen loading estimate. The effluent nitrogen concentration in just one of these, (Malibu Inn and Restaurant) was estimated to be 110 mg/L at a flow rate of 6,200 gal/day, which means that the discharge from this one facility constituted over 13% of the total commercial nitrogen load. Given the impact of the commercial discharges with high nitrogen on the total loading estimate, it is advisable that samples be taken verify the high nitrogen discharge numbers, particularly if the nitrogen concentration estimates were based on the TN:BOD ratio characteristic of residential wastewater. Moreover, characterization of the uncertainty in these estimates, incorporating better values of restaurant wastewater from the literature, and perhaps analysis of the sensitivity of the total nitrogen loading rate to estimated high nitrogen loading rates should be done.

c. *Staff's characterization of groundwater flow regimes in the Malibu Civic Center area into five hydrogeologic sectors, and staff's application of the nitrogen loads (calculated from #2 above [should be b?]) into a spreadsheet model that estimates attenuation of nitrogen loads released from OWDS's and transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon) for each hydrogeologic sector.*

Division of the region into topographic and hydrogeologic sectors to calculate groundwater flow and associated nitrogen loading rates to the Malibu Lagoon, summarized in Table 3, is a good approach. Estimates of attenuation of nitrogen in SWIS's were very conservative, from 0 to 20%; whereas typical estimates in the literature ranged from 10 – 40% based on soil type. Given that most of the soil in the region was high permeability sand and silt, this may be reasonable. It appeared that the 0% removal was applied when the depth to the ground water table was < 5 ft, regardless of soil characteristics. The other assumption was that nitrate could be used as a surrogate for total nitrogen discharged to the groundwater. This assumes significant nitrification (bacterial oxidation of ammonia to nitrate) in the unsaturated zone, which is supported by the literature. In one case study, the average nitrate concentration in a fine sand SWIS peaked at 21.6 mg/L NO_3-N at a depth of 0.6 m (2 ft), but was still high, 13 mg/L NO_3-N, after percolating to a depth of 1.2 m (4 ft), although there was clearly some attenuation, probably by denitrification, even in the sandy soil (USEPA, 2002). Particularly in wastewater SWIS systems, there will be residual organic matter in the soil that can be used by denitrifying bacteria to reduce nitrate to N_2 gas, so the zero attenuation factor for shallow groundwater table may be too conservative. As with the nitrogen loading estimates, it would be useful to perform a sensitivity analysis for SWIS (leach field) attenuation estimates. Also, if there are monitoring wells near leach fields, nitrate concentrations could be measured to verify these estimates.

d. *Staff's use of the updated nitrogen loads released from OWDS's (calculated from #2 [b?] above) to adjust (update) estimates of nitrogen transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon), using a relationship already established by a groundwater flow and transport model (which is already accepted by stakeholders in the community).*

The staff's estimate of total nitrogen loading to Malibu Lagoon using the spreadsheet model (Table 4) was 36 lb/day with 38% of the TN mass loading from OWDS reaching the Lagoon, compared with 32% in the numeric model. There is an inconsistency between the spreadsheet column estimate in Table 4 and Table 1 in Attachment 4-1 (page T4-41). In the attachment Table 1, the ratio is given as 40%, with an associated mass loading of 35.7 lb/day. This is a small discrepancy, and may just be rounding difference. However since all the input data are the same, the two tables should be consistent for the spreadsheet estimate. An overall concern is that the rationale for increased commercial loading was not clear, either in section 2.2 of Attachment 4-1 or in Section 3 of the Report (page 4-13-14). Commercial flows increased, but this was captured in the nitrogen loading estimates. The possibility of exceeding soil uptake capacity for nitrogen removal was mentioned in section 2.2 of Attachment 4-1, but there was no indication of how this resulted in an increase in the fraction of the nitrogen reaching Malibu Lagoon from 32 to 38% (or 40% in Attachment Table 1).

The CSTR model used to compare the estimate mass loading to measured nitrogen concentrations was interesting and appears to support the higher estimates of nitrogen loading to the Lagoon. However, the non-point source nitrogen contributions to the Lagoon did not appear to have been factored in. If these are available from the TMDL calculation, they should be considered as part of the total load.

General comments.

Check document for typos, grammatical errors and erroneous callouts. Examples:
p. T4-2, para. 4, line 5: "conservation" should be conservative.
p. T4-3, last line: "facility" should be facilities.
p. T4-5, para 4, line 1 should read: For wastewater generated by commercial facilities...
p T4-6, para 1, line 3 should read: Since 2001, the inventory of commercial properties (delete "on")
p. T4-6, para 5, line 4 should read: Using reported or estimated wastewater (delete second "using")
page T4-7, section Assumptions for Residential Flow and Total Nitrogen Concentration. The estimate of 100 gallons per day per bathroom is for water use, not wastewater generation. You appear to have made the assumption that wastewater generation = water use. This is generally not the case, and Metcalf and Eddy is not correctly cited. (See comments in part a). Also, instead of using the unit 100 gallons per person, the usual unit is gallons per capita per day (gpcd).

Use appropriate significant figures, especially in Tables. Calculated values with 4-6 significant figures do not reflect the input information.

Overarching questions

(a) The scientific basis for the proposed rule, regarding nitrogen discharges from OWDS's to Malibu Lagoon includes estimates not based on site data but literature values, some of which can be questioned (see specific comments in parts a, b, and c above). Overall, a higher scientific standard would be achieved by better characterization of the uncertainty in the estimates, careful use the most recent literature, and analysis of the sensitivity of the results to variation of key input parameters such as flow rates, effluent nitrogen concentrations from OWDS's, and soil attenuation factors.
(b) Even with the concerns above, the general approach and methods used in Technical Memorandum #4 incorporate sound scientific and engineering principles. Adjustments based on less conservative assumptions could lower the OWDS nitrogen loading rate, even by as much as one-third. However, even the lowered loading rate would still far exceed the TMDL, and the conclusion in the Memorandum that the 6 lb/day maximum loading rate for wastewater nitrogen will not being achieved using OWDS's is reasonable and justified.

References

Converse, J.C., R.L. Siegrist, and D.L. Anderson, Onsite Treatment and Disposal of Restaurant Wastewater, Report 10.13, Small Scale Waste Management Project, Univ. Wisconsin, 1984.

Metcalf and Eddy, Wastewater Engineering Treatment and Reuse, 4th Ed., McGraw-Hill, NY. 2003.

USEPA, National Risk Management Research Laboratory, Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, Washington, DC. 2002.